FABRICATION OF ECHELON GRATINGS BY SOL-GEL MOLDING METHOD

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1. INTRODUCTION

The explosion of the internet supported by the DWDM communication system is creating a new information-oriented society. The multiplexing and demultiplexing in the wavelength domain is the most fundamental technology of the DWDM. Thin film devices, fiber gratings, AWG and diffraction gratings are used in this technology. Since the diffraction grating is one of the fundamental elements that separate light wave corresponding to its wavelength, it is widely used in the field of spectroscopy. However, when we use the current diffraction grating for the DWDM telecom components, it has two problems, polarization dependency and durability. Echelon gratings, which have several tens of microns in grooving height, resolve polarization dependency.

By the way, we have studied the fabrication process of grooves on glass substrates for optical memory disks by using the sol-gel method [1-3]. This method is suitable for fabricating grooves of sub-micron depth. In recent years, we proposed a technique to fabricate durable micro-lens arrays, which have a pattern of several tens of microns in thickness, by molding the organic-inorganic sol-gel material composed of phenlytriethoxysilane(PTES) and dimethlydiethoxysilane(DEDMS)[4,5].

In this paper, we report the novel echelon gratings fabricated from the organic-inorganic sol-gel material composed of PTES and DEDMS.

2. EXPERIMENT

Figure 1 illustrates the preparation of NSG sol-gel solution and fabrication process of sol-gel molding. Coating solution was prepared in the following manner. PTES and DEDMS were mixed with ethanol, water and acidic catalyst. This solution was stirred at room temperature for 30 minutes to hydrolyze. Thus the clear and homogeneous solution was obtained as NSG sol-gel solution.

The mold prepared to make echelon gratings in this experiment was grooved 25μm in pitch and 17μm in height, and its grating area was 12 mm square. The sol-gel solution was poured onto the mold and pre-heated to gelation on the hot plate. After gelation, a clean silica glass substrate was put onto the gel film and pressed 200℃ without vacuum condition. After the mold was released from sol-gel material, the sample was baked 250℃. Gold thin film as reflection coating was coated on the sol-gel material, then sol-gel echelon type gratings on the substrates were obtained.

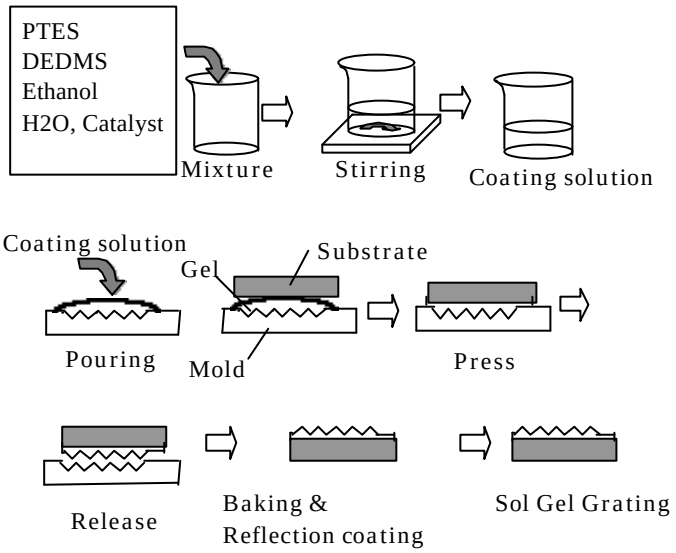
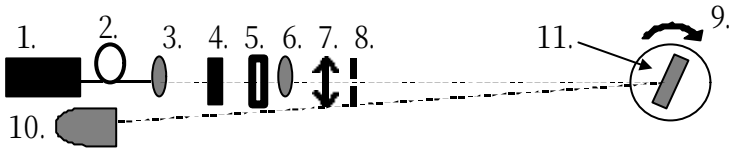


Fig. 1 Fabrication process of sol-gel gratings

The shape of sol-gel echelon gratings was observed by scanning electron microscope (SEM), and diffraction efficiency at 1550nm was measured by the optical system, where tunable semiconductor laser, polarizer and optical power meter were shown in Figure 2. Wavefront distortion was measured by MARK GPIxps(Zygo Inc.). As durability tests, the thermal shock test was conducted by first placing a sample on the hot plate heated to 350℃, then moving it to a metal stage at room temperature. Humidity resistance test was also done at the condition of 85℃-85%RH for 500 hours.



Components

1. Light source	7. Achromatic collimator
2. Fiber	8. Diaphragm
3. Collimator	9. Sample stage
4. λ/4 phase plate	10. Photodetector
5. Polarizer	11. Grating sample
6. Confocal lens	

Fig. 2 Optical system to measure diffraction efficiency

3. RESULT AND DISCUSSION

The obtained samples were crack free and good appearance. Figure 3 shows a SEM image of the cross section of sol-gel echelon grating. It was confirmed that pitch and height of sol-gel grating were consistent with ones of the mold in SEM image. Since the results indicate that the low shrinkage from the gel material after pre-heat treatment, we consider that the composition of PTES and DEDMS is effective to the process.

Diffraction efficiencies of s- and p- polarization at 1550nm of the echelon gratings were 37.9% and 37.6%, which corresponds to a polarization dependent loss less than 0.1dB. Wavefront distortion was 2.2 μm at P-V value, 0.43 μm at Rms value and it has good flatness (Figure 4). These optical properties indicate that this sol-gel molding method can be applied to fabricate echelon gratings, which have a pattern of several tens of microns in thickness.

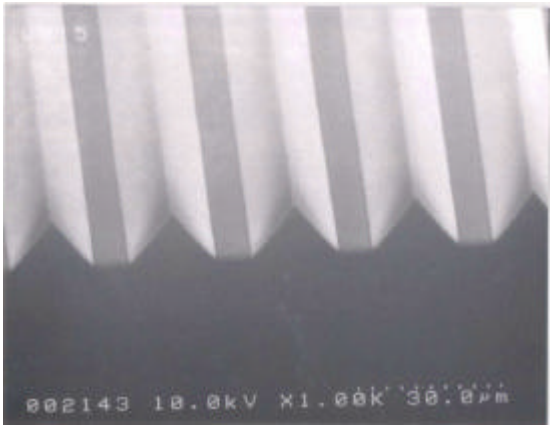


Fig. 3 SEM image of cross section of sol-gel echelon grating

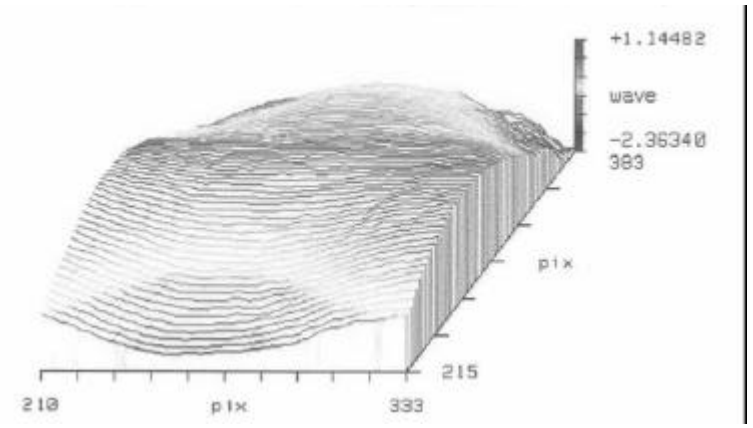


Fig. 4 Wavefront distortion of sol-gel echelon grating

In addition, there was no change in appearance after the thermal shock test. After humidity resistance test, diffraction efficiency of the sol-gel echelon gratings was changed less than 1%. This high durability shows that sol-gel echelon gratings have significant advantages to heat-stability during assembly process and to durability for the environment.

4. CONCLUSION

Echelon gratings were fabricated on glass substrate by molding method using sol-gel material composed of PTES and DEDMS. The sol-gel echelon gratings show good optical properties that diffraction efficiency is 37.6-37.9% and polarization dependent loss is less than 0.1dB. And they show good durability to thermal shock and humidity resistance. The sol-gel molding method used with PTES and DEDMS will bring about new possibility in the DWDM devices.

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